National Aeronautics and Space Administration

NASA facts

Space Technology

Game Changing Development

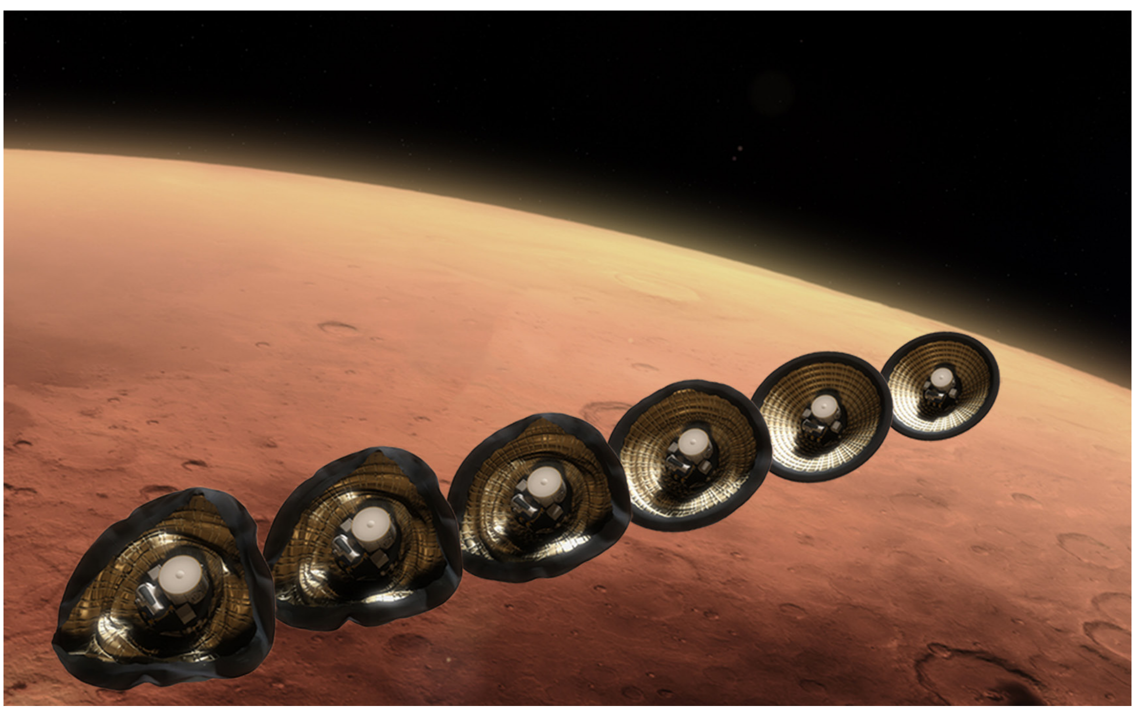
Hypersonic Inflatable Aerodynamic Decelerator (HIAD)

The Hypersonic Inflatable Aerodynamic Decelerator (HIAD) project is a disruptive technology that will accommodate the atmospheric entry of heavy payloads to planetary bodies such as Mars. HIAD overcomes size and weight limitations of current rigid systems by utilizing inflatable soft-goods materials that can be packed into a small volume and deployed to form a large aeroshell before atmospheric entry.

The HIAD design consists of an inflatable structure that addresses the drag forces, and a protective flexible thermal protection system (F-TPS) that combats the thermal loading.

Hypersonic spacecraft entering the atmospheres of planets are traveling so fast that they create a high-energy pressure wave. This pressure wave entraps and rapidly compresses atmospheric gases, resulting in drag forces that decelerate the vehicle and thermal loads that heat the vehicle.

Normally, flexible materials would not be able to withstand the drag forces a spacecraft would encounter during atmospheric entry; however, the inflatable structure is constructed out of a fastened series of pressurized concentric tubes, or tori, that form an exceptionally strong blunt cone-shaped structure. The tori are constructed from braided synthetic fibers that are 15 times stronger than steel. Though the inflatable structure has the capability to withstand temperatures beyond 400° C, the HIAD relies on the F-TPS to survive entry temperatures.



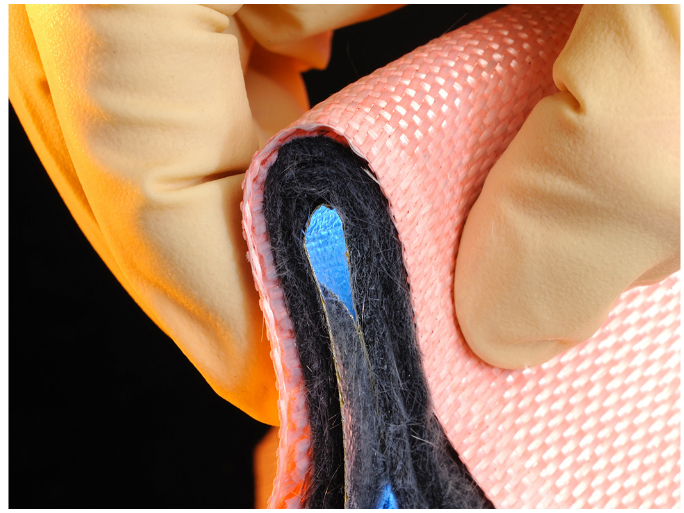
The F-TPS, which covers the inflatable structure and insulates it from the searing heat of atmospheric entry, can be separated into three functional layers: an exterior ceramic fiber cloth layer that can maintain integrity at surface temperatures in excess of 1600° C, protecting the underlying insulation from the aerodynamic shear forces; a middle layer of high-temperature insulators that inhibit heat transmission; and an interior impermeable gas barrier layer that prevents hot gas from reaching the inflatable structure.

HIAD technology has several other benefits over existing rigid technologies, including lower volume, lower total system weight and deceleration at higher altitudes than smaller area rigid heat shields. In addition, aeroshell size is scalable to fit missions with different payload mass requirements and launch vehicle fairing limitations. This mission flexibility provides new opportunities for robotic and human exploration missions previously deemed infeasible.

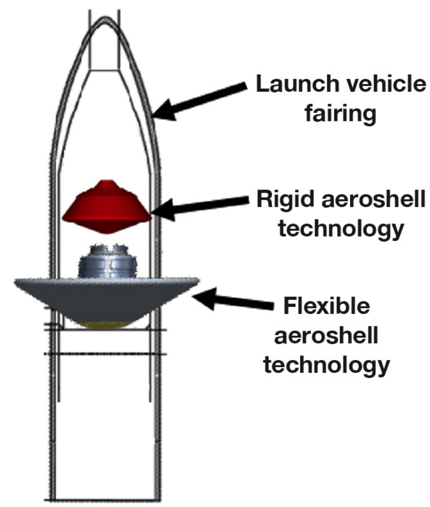
Since the beginning of its development in 2007, several ground-based advancements and two successful flight tests have provided a team of engineers at NASA Langley Research Center valuable data they have used to refine the HIAD technology. The Inflatable Reentry Vehicle Experiment 3, or IRVE-3, suborbital launch of a 300-kg payload to a height of 460 km on July 23, 2012, was the most recent HIAD test flight. The IRVE-3 flight test successfully demonstrated the ability of a HIAD to decelerate the payload from an entry speed of more than Mach 10 with drag forces approaching 20 g's. The IRVE-3 flight also demonstrated the ability to generate vehicle lift and stable flight through transonic and subsonic entry speeds.

Through iterative successes, HIAD technology continues to show great promise as a strong candidate for mission infusion, and is paving the way for future human access to Mars by challenging past conceptions of entry, decent and landing technologies.

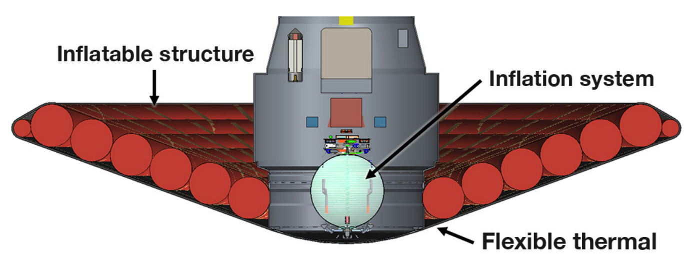
The Game Changing Development (GCD) Program investigates ideas and approaches that could solve significant technological problems and revolutionize future space endeavors. GCD projects develop technologies through component and subsystem testing on Earth to prepare them for future use in space. GCD is part of NASA's Space Technology Mission Directorate.



Flexible thermal protection system.



Flexible aeroshell is not limited by launch vehicle fairing size.



Concept 6-meter HIAD.

For more information about GCD, please visit http://gameon.nasa.gov/

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